US 20060032586A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2006/0032586 A1**

Choi et al. (43) **Pub. Date: Feb. 16, 2006**

(54) **REDUCING ELECTROSTATIC CHARGE BY ROUGHENING THE SUSCEPTOR**

(75) Inventors: **Soo Young Choi**, Fremont, CA (US); **Beom Soo Park**, San Jose, CA (US); **Quanyuan Shang**, Saratoga, CA (US); **John M. White**, Hayward, CA (US); **Dong-Kil Yim**, Sungnam-City (KR); **Chung-Hee Park**, Seoul (KR)

Correspondence Address:
PATTERSON & SHERIDAN, LLP
3040 POST OAK BOULEVARD, SUITE 1500
HOUSTON, TX 77056 (US)

(73) Assignee: **APPLIED MATERIALS, INC.**

(21) Appl. No.: **11/182,168**

(22) Filed: **Jul. 15, 2005**

Related U.S. Application Data

(63) Continuation-in-part of application No. 10/435,182, filed on May 9, 2003.

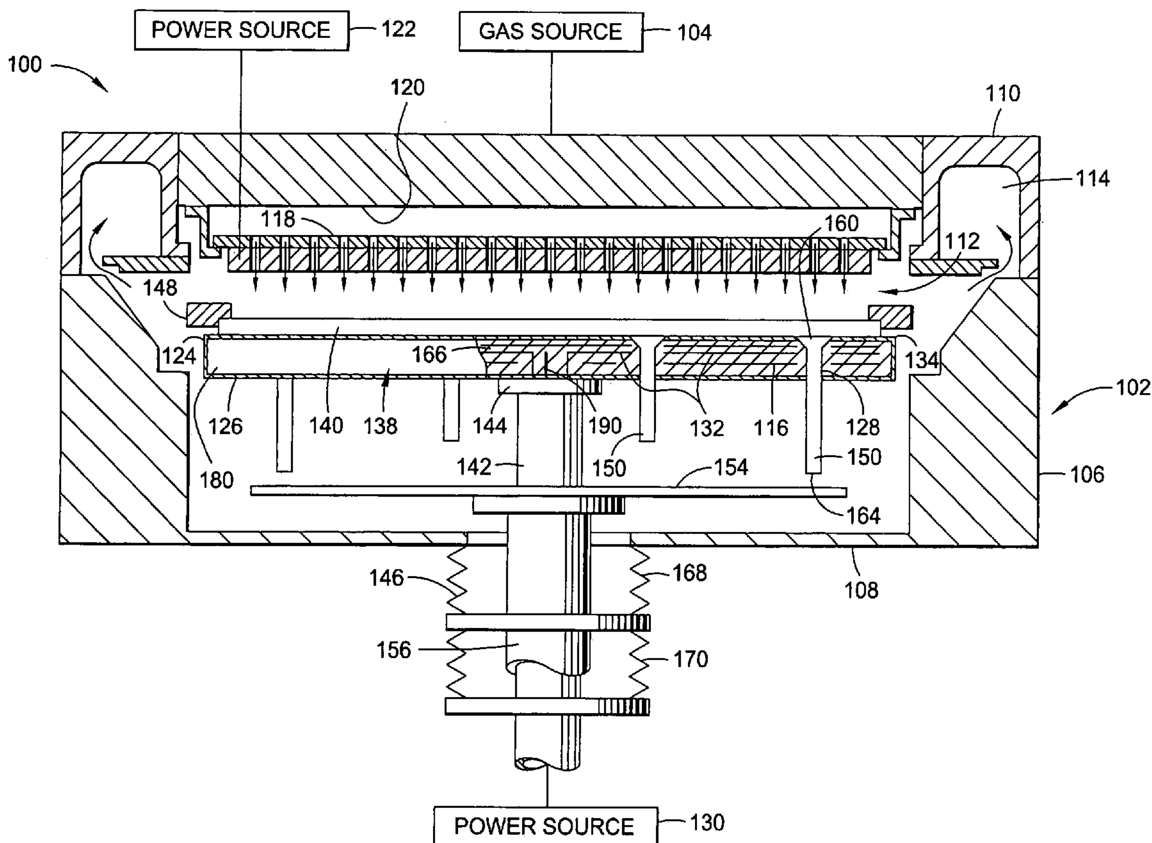
Publication Classification

(51) **Int. Cl.**
H01L 21/306 (2006.01)

(52) **U.S. Cl.** **156/345.51**

(57) **ABSTRACT**

A substrate support and method for fabricating the same are provided. In one embodiment of the invention, a substrate support includes an electrically conductive body having a substrate support surface that is covered by an electrically insulative coating. At least a portion of the coating centered on the substrate support surface has a surface finish of between about 200 to about 2000 micro-inches. In another embodiment, a substrate support includes an anodized aluminum body having a surface finish on the portion of the body adapted to support a substrate thereon of between about 200 to about 2000 micro-inches. In one embodiment, a substrate support assembly includes an electrically conductive body having a substrate support surface, a substrate support structure that is adapted to support the conductive body and the conductive body is covered by an electrically insulative coating.



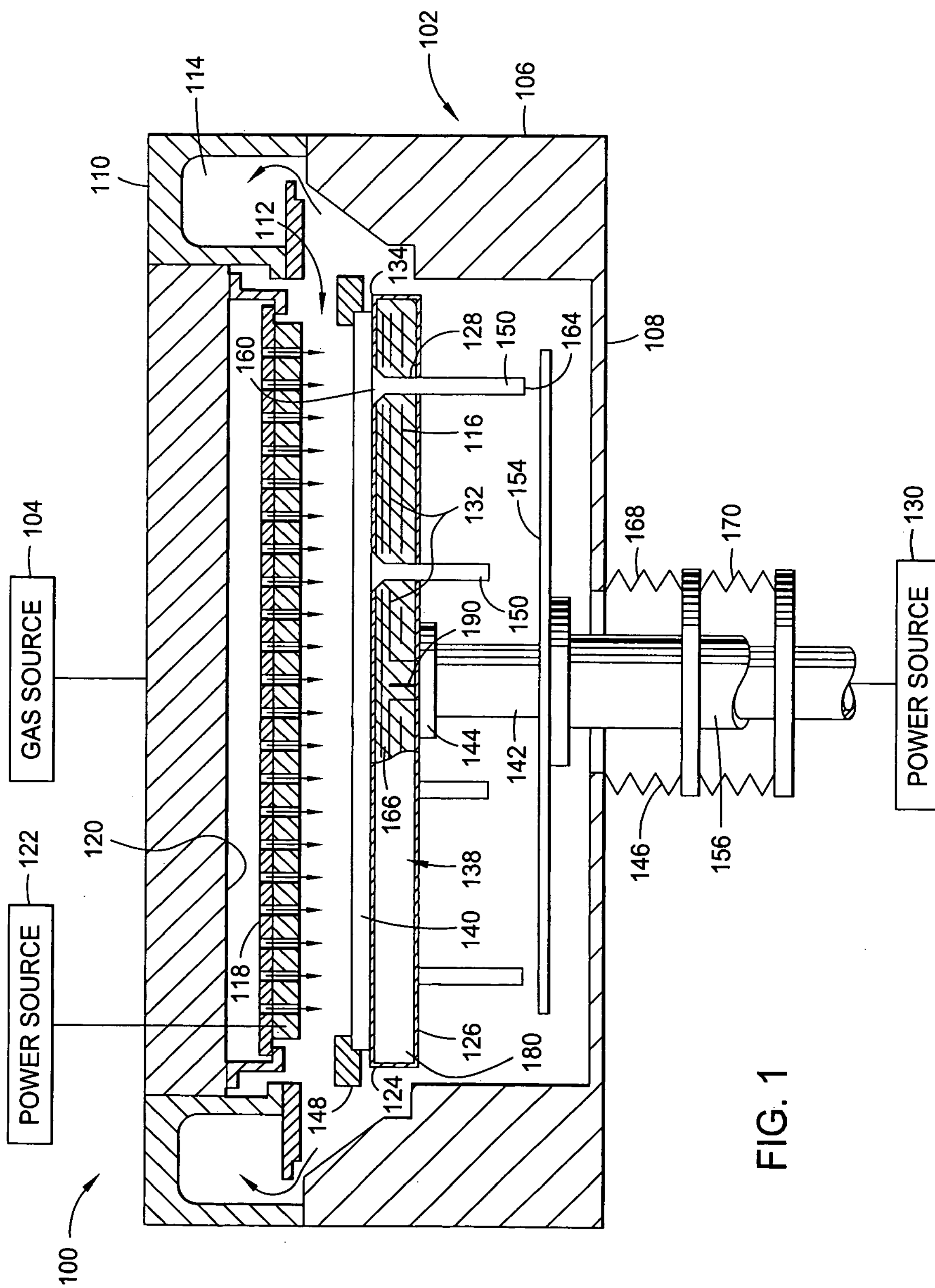


FIG. 1

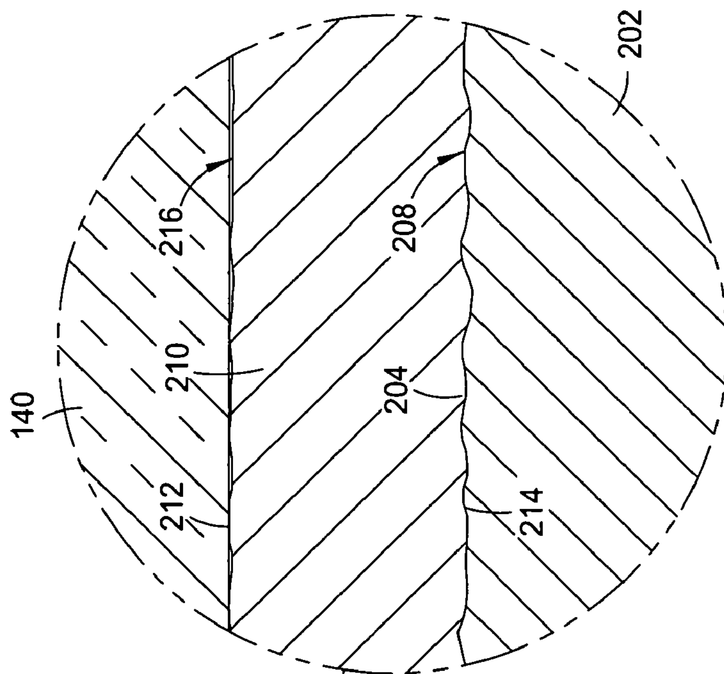


FIG. 2A

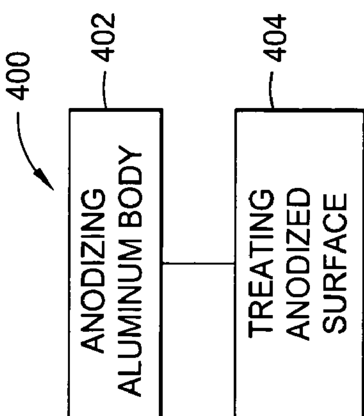


FIG. 4

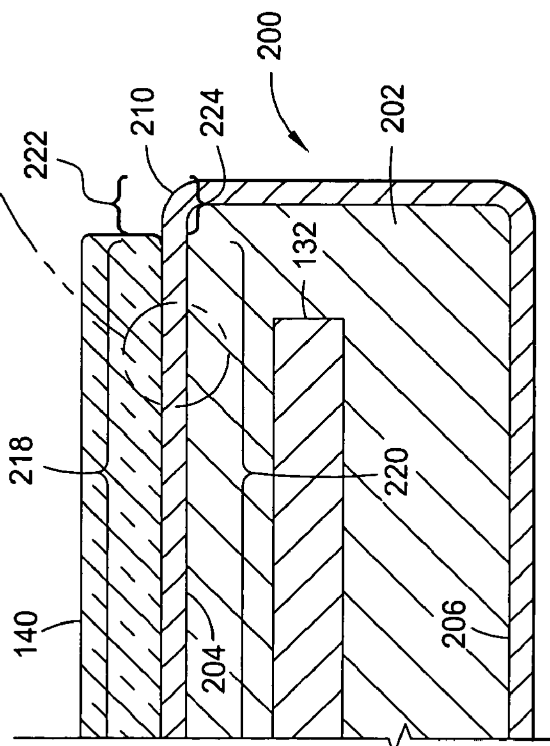


FIG. 2

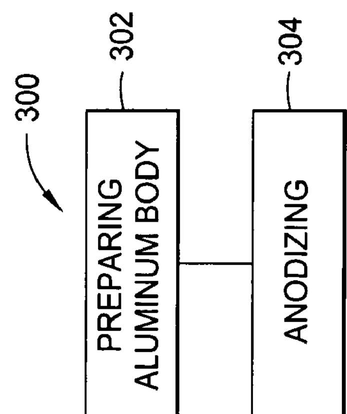


FIG. 3

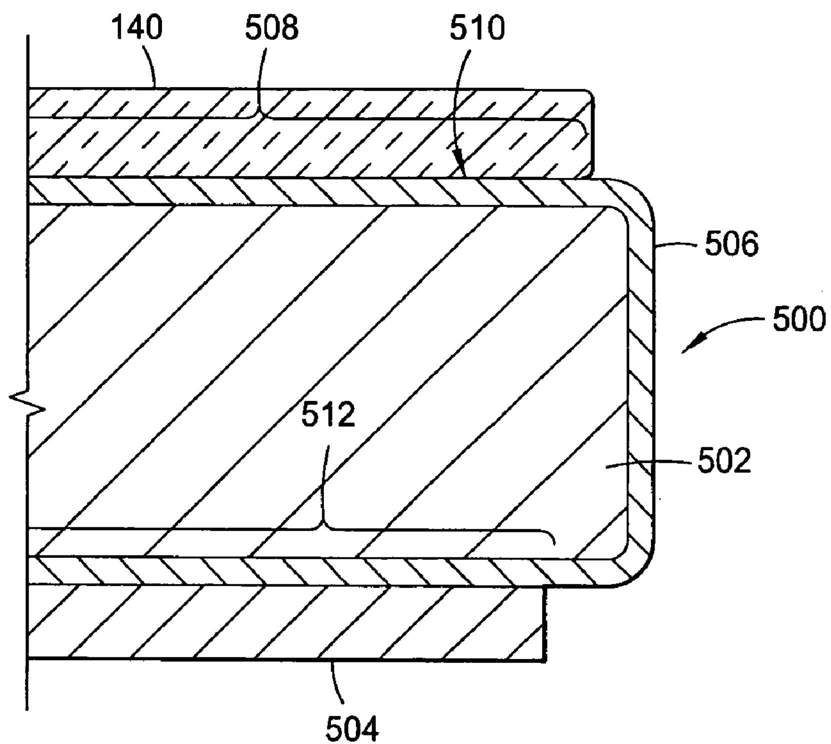


FIG. 5
140
508
510
506
500
512
502
504

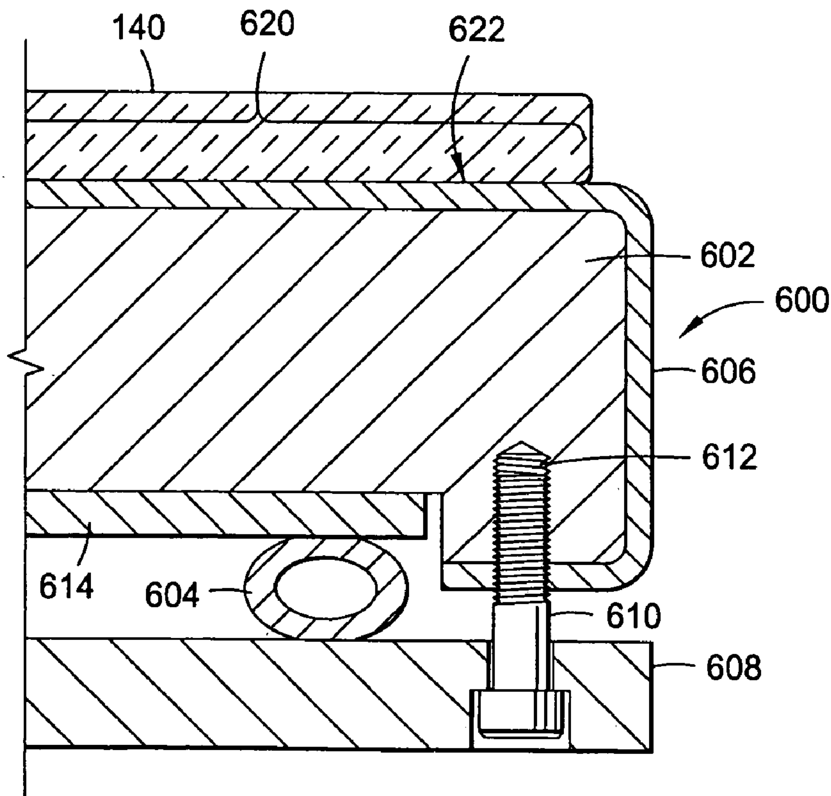


FIG. 6
140
620
622
602
600
606
612
614
604
610
608

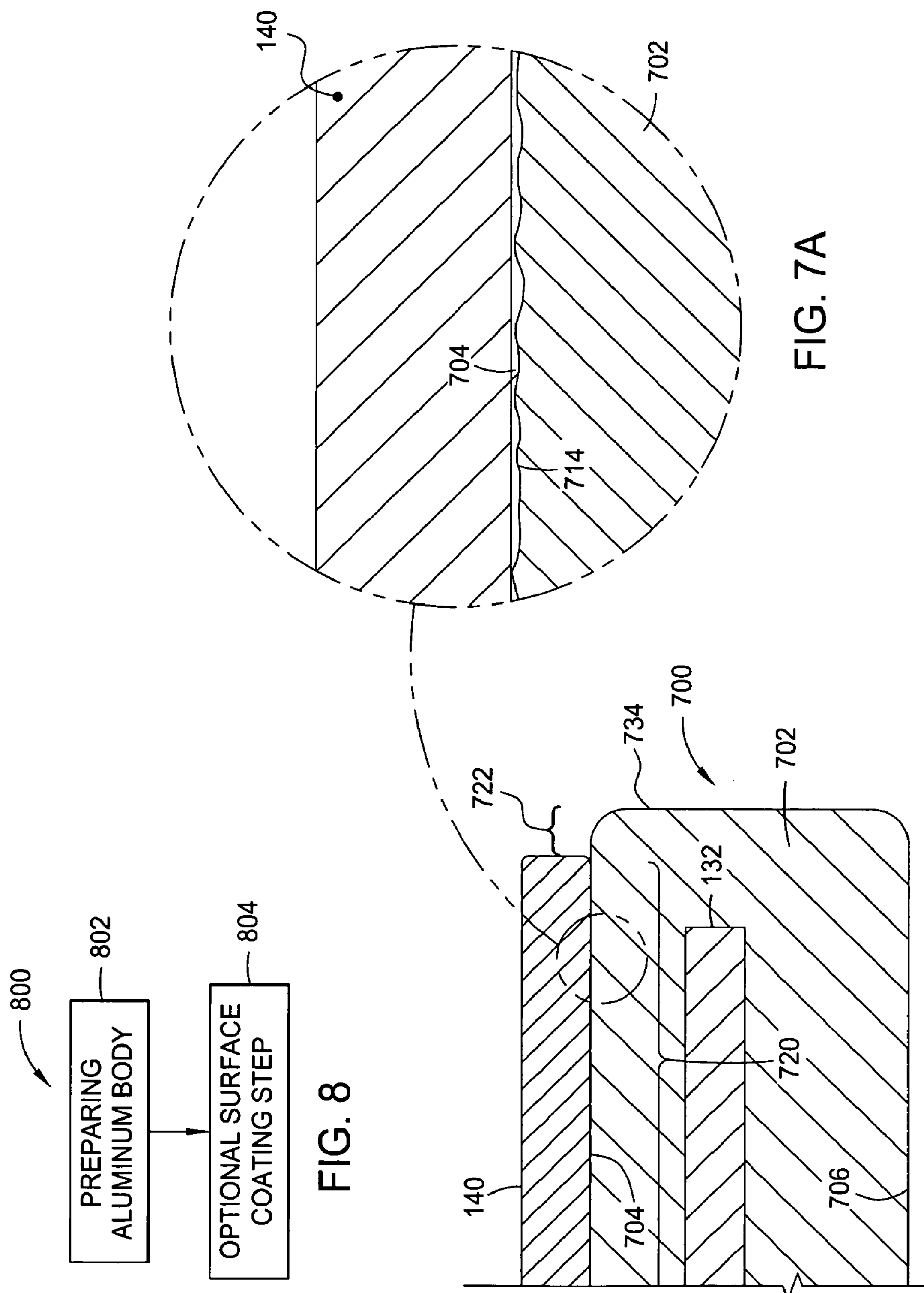


FIG. 7A

FIG. 7

FIG. 8

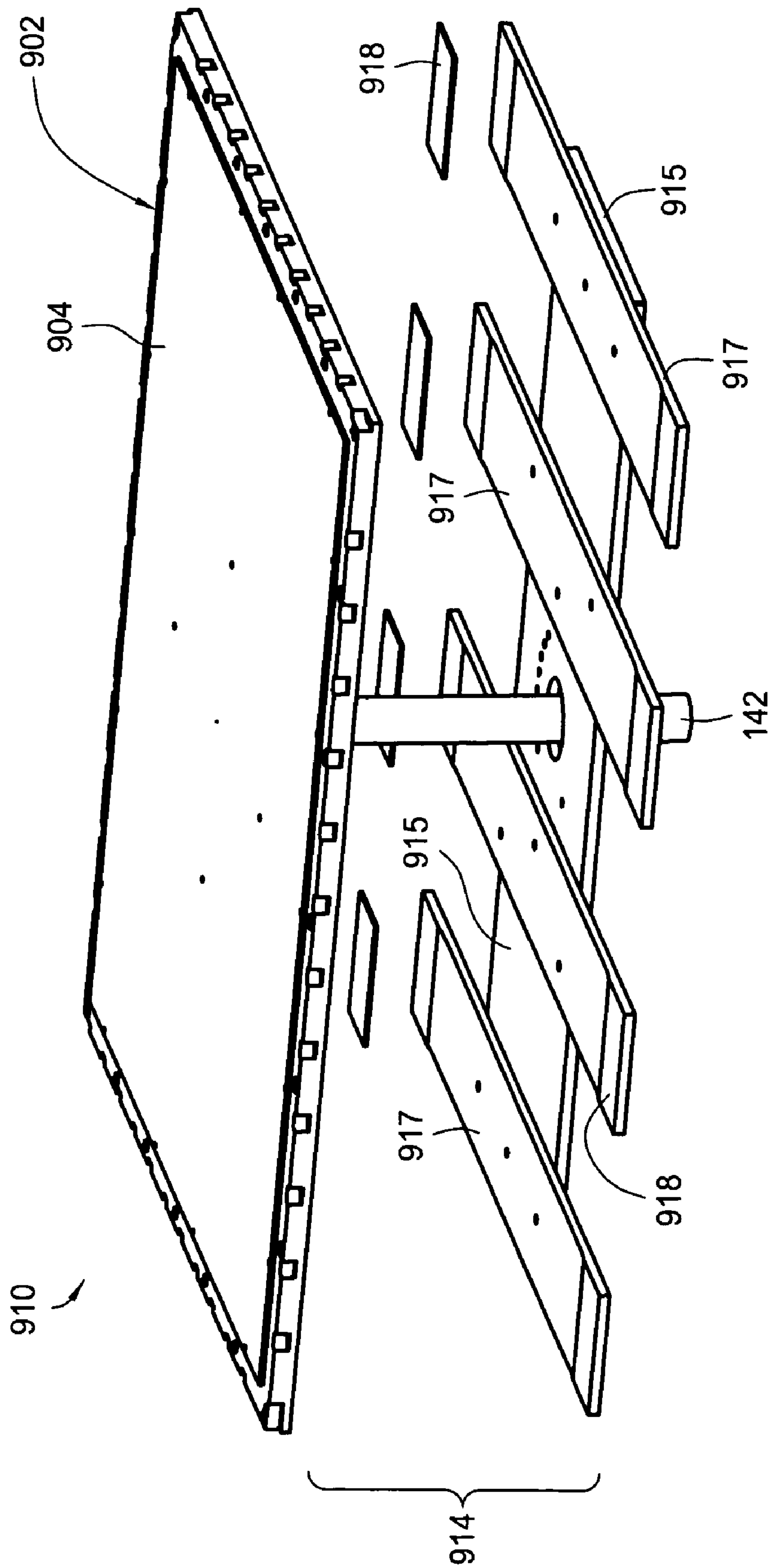


FIG. 9

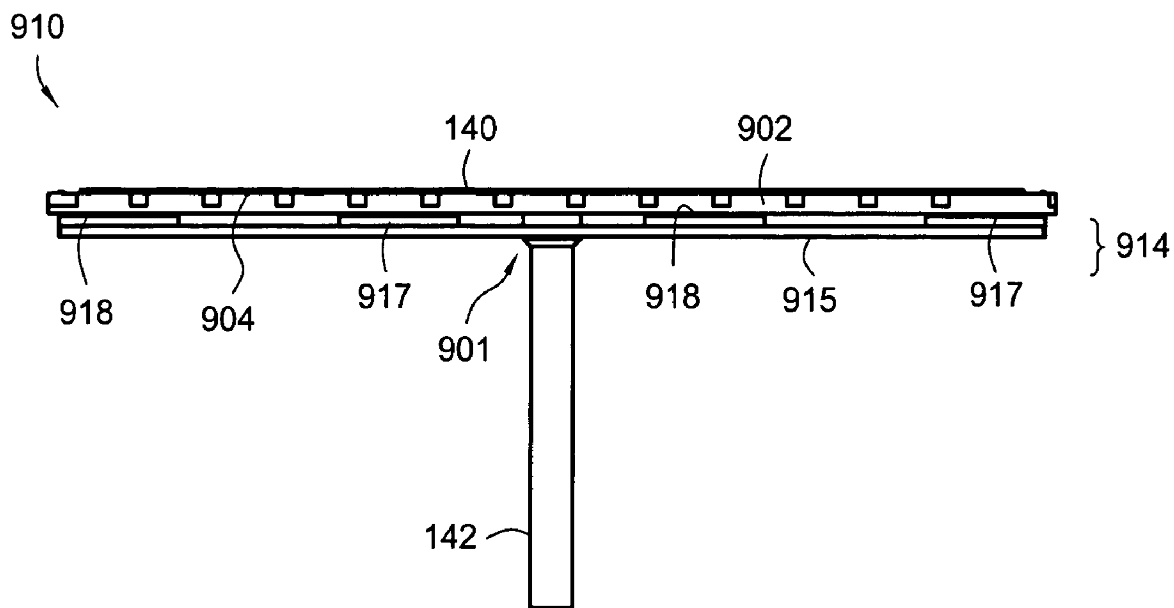


FIG. 10

REDUCING ELECTROSTATIC CHARGE BY ROUGHENING THE SUSCEPTOR

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation-in-part of co-pending U.S. patent application Ser. No. 10/435,182, filed May 9, 2003, which is herein incorporated by reference.

BACKGROUND OF THE DISCLOSURE

[0002] 1. Field of the Invention

[0003] Embodiments of the invention generally provide a substrate support utilized in semiconductor processing and a method of fabricating the same.

[0004] 2. Description of the Background Art

[0005] Liquid crystal displays or flat panels are commonly used for active matrix displays such as computer and television monitors, personal digital assistants (PDAs), cell phones and the like. Generally, flat panels comprise two glass plates having a layer of liquid crystal material sandwiched therebetween. At least one of the glass plates includes at least one conductive film disposed thereon that is coupled to a power supply. Power supplied to the conductive film from the power supply changes the orientation of the crystal material, creating a pattern such as text or graphics seen on the display. One fabrication process frequently used to produce flat panels is plasma enhanced chemical vapor deposition (PECVD).

[0006] Plasma enhanced chemical vapor deposition is generally employed to deposit thin films on a substrate such as a flat panel or semiconductor wafer. Plasma enhanced chemical vapor deposition is generally accomplished by introducing a precursor gas into a vacuum chamber that contains a substrate. The precursor gas is typically directed through a distribution plate situated near the top of the chamber. The precursor gas in the chamber is energized (e.g., excited) into a plasma by applying RF power to the chamber from one or more RF sources coupled to the chamber. The excited gas reacts to form a layer of material on a surface of the substrate that is positioned on a temperature controlled substrate support. In applications where the substrate receives a layer of low temperature polysilicon, the substrate support may be heated in excess of 400 degrees Celsius. Volatile by-products produced during the reaction are pumped from the chamber through an exhaust system.

[0007] Generally, large area substrates utilized for flat panel fabrication are large, often exceeding 550 mm×650 mm, and are envisioned up to and beyond 4 square meters in surface area. Correspondingly, the substrate supports utilized to process large area substrates are proportionately large to accommodate the large surface area of the substrate. The substrate supports for high temperature use typically are casted, encapsulating one or more heating elements and thermocouples in an aluminum body. Due to the size of the substrate support, one or more reinforcing members are generally disposed within the substrate support to improve the substrate support's stiffness and performance at elevated operating temperatures (i.e., in excess of 350 degrees Celsius and approaching 500 degrees Celsius to minimize hydrogen content in some films). The aluminum substrate support is then anodized to provide a protective coating.

[0008] Although substrate supports configured in this manner have demonstrated good processing performance, small local variations in film thickness, often manifesting as spots of thinner film thickness, have been observed which may be detrimental to the next generation of devices formed on large area substrates. It is believed that variation is glass thickness and flatness, along with a smooth substrate support surface, typically about 50 micro-inches, creates a local capacitance variation in certain locations across the glass substrate, thereby creating local plasma non-uniformities that result on deposition variation, e.g., spots of thin deposited film thickness. Aging and modifying plasma conditioning of the substrate support has shown to mitigate thin spot formation, particularly when performed in conjunction with an extended chamber vacuum purge before transferring a substrate into the chamber for processing. However, the resultant expenditures of time and materials required by this method and its unfavorable effect on cost and throughput make obtaining a more effective solution desirable.

[0009] As substrates sizes have increased from sizes from about 370 mm×470 mm to about 1200 mm×1040 mm, or even 1800 mm×2200 mm, other new defect modes have become critical issues in the fabrication of the flat panel display devices. As the size of next generation of substrates continue to grow, the importance of defect reduction becomes increasingly important due to the substantial investment by the flat panel manufacturer in each substrate. Moreover, with the continual evolution of device critical dimension reduction demanding closer tolerances for film uniformity, the reduction and/or elimination of film thickness variation becomes an important factor for the economic production of the next generation devices formed on large area substrates.

[0010] Moreover, the effectiveness of a substrate fabrication process is often measured by two related and important factors, which are device yield and the cost of ownership (CoO). These factors are important since they directly affect the cost to produce an electronic device and thus a device manufacturer's competitiveness in the market place. The CoO, while affected by a number of factors, is greatly affected by the initial cost of the processing hardware and the replacement cost of consumable hardware. In an effort to reduce CoO, electronic device manufacturers often spend a large amount of time trying to optimize the processing hardware and consumable cost to achieve the greatest the highest profit margins without affecting the particle and process yield performance. Another important factor in the CoO calculation is the system reliability and system uptime. These factors are very important to a cluster tool's profitability and/or usefulness, since the longer the system is unable to process substrates the more money is lost by the user due to the lost opportunity to process substrates in the cluster tool. Therefore, cluster tool users and manufacturers spend a large amount of time trying to develop reliable processes, reliable hardware and reliable systems that have increased uptime.

[0011] One defect that has been found to be an issue in large area substrate PECVD type processes is a defect known in the industry as the electro-static discharge (ESD) metal line arcing problem. It is believed that as the substrate size increased the inductive current induced in the longer and larger ESD metal lines during plasma deposition is large enough to make the damage to the substrate from plasma

induced arching a major recurring problem. This problem is generally not experienced in the smaller semiconductor device fabrication applications (e.g., 150 mm to 300 mm circular silicon substrates) since the gate-metal lines in flat panel display applications, which are connected to the ESD discharge line, are generally about 5 to 10 micrometers (μm) wide and can be about a meter or two meters long whereas in typical semiconductor application gate-metal lines are on the order of 90 nanometers size at most tens of millimeters long. The width of the ESD lines in the flat panel display substrates is typically greater than 1 mm in size and can be between about a meter or two meters long. It is believed that the ESD metal lines in flat panel display applications thus tend to act as an antenna that can collect an amount of charge during plasma processing that will cause arching damage to the substrate. Therefore, there is a greater need to reduce the chance of arcing due to the interaction with the plasma by increasing the resistance of the discharge path to ground. It should be noted that the thickness of the flat panel substrates (e.g., 0.7 mm), which is much larger than semiconductor substrates, has not changed dramatically from the large and smaller sized flat panel display type substrates.

[0012] Another defect that has arisen in the processing of 1200 mm×1040 mm, or larger substrates, is an increased in the number of particles found on the backside of the substrate after performing a plasma process on the substrate, such as a PECVD process. It is believed that as the glass substrate size increases the ability to trap static charge during plasma processing increases, thus causing particles found in the processing chamber to be attracted to the substrate surface where they are held by the trapped charge.

[0013] The issue of arcing and static charge is believed to be different in flat panel display applications versus semiconductor applications due to the size and properties of the different substrate materials. The static charge generated by the triboelectric process, or the process of bringing two materials into contact with each other and then separating them from each other, is influenced by a number of factors, two of which are the amount of surface contact between the two components and the work function of the two materials. One difference between flat panel and semiconductor applications is the difference in the properties of the substrate material(s) used in each of these applications (e.g., glass versus silicon (or germanium)), which is related to a material property known as its work function. In general, the work function describes a material's ability to hold onto its free electrons (the electrons orbiting the outer most shell of the material). In general, materials with larger work functions (e.g., silicon) are less likely to give up their electrons than a material that has a lower work function (e.g. glass) when they are placed in contact with a given material and then separated from the material. (See reference "Triboelectric Generation: Getting Charged" in EE-Evaluation Engineering, November, 2000 written by Ryne C. Allen.) Therefore, while the static charge generation issue is dependent on the materials which the processed substrate comes in contact with, the amount of charge and the polarity of the charge generated in a flat panel display substrate versus a semiconductor substrate will not be the same.

[0014] The second triboelectric factor, or the amount of contact between the parts, means that the greater the contact between the components the more charge that will be transferred between the contacting components and possibly arcing. The amount of surface roughness of the two components has a direct affect on the amount of contact between the two parts. Therefore, while some prior art application, such as U.S. Pat. No. 6,063,203 filed Jun. 2, 1998 suggest a process of roughening the surface of a susceptor (substrate support) to an R_a of between 1 and 8 micrometers, the reference requires a final step of polishing the roughened susceptor surface which reduces the roughness and increase the contact between the two substrate components. The reduced roughness, and thus increased contact between the two substrate components, will increase the triboelectric charge transfer between the substrate and the substrate support, thus increasing the likelihood of generating enough trapped charge to form an arc or attract particles. An alternate theory is that the step of polishing a roughened surface, as described in the prior art, is thought to remove some of the benefits received from roughening the surface of the substrate support, such as an improved electrical contact between the two parts (i.e., susceptor surface and glass substrate). The improved electrical contact is believed to be created by the higher contact stress at the sharp tips or high points of the roughened surface, which is thought to reduce the charge buildup between the two parts during plasma processing, thus reducing the chance of arcing and particle attraction to the substrate surfaces.

[0015] Therefore, there is a need for an improved substrate support that resolves all of these issues raised above.

SUMMARY OF THE INVENTION

[0016] A substrate support and method for fabricating the same are provided. In one embodiment of the invention, a substrate support includes an electrically conductive body having a substrate support surface, an electrically insulative coating disposed on the body and at least a portion of the coating disposed over a center of the substrate supporting surface having a surface finish between about 200 to about 2000 micro-inches.

[0017] In one embodiment, a substrate support is adapted to support large area substrates comprising a body having a substrate support surface, a substrate support structure having one or more supports that are adapted to structurally support the body during processing and an electrically insulative coating disposed on the substrate support surface treated after deposition to a surface finish between about 200 to about 2000 micro-inches.

[0018] In another embodiment, a substrate support is fabricated by a process including the steps of providing an aluminum body suitable for supporting a large area substrate on a substrate support surface, and forming an anodized coating having a surface roughness of between about 330 to about 2000 micro-inches on the substrate support surface.

[0019] In yet another embodiment, a substrate support adapted to support large area substrates comprising an electrically conductive body having a substrate support surface, wherein the substrate support surface is bare aluminum and has a surface finish between about 140 to about 2000 micro-inches.

[0020] In yet another embodiment, a substrate support adapted to support large area substrates comprising a bare aluminum body having a substrate support surface treated to a surface finish of about 140 to about 1000 micro-inches;

and a substrate support structure having one or more supports that are adapted to structurally support the aluminum body during processing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] A more particular description of the invention, briefly summarized above, may be had by reference to the embodiments thereof that are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

[0022] **FIG. 1** depicts a schematic sectional view of one embodiment of a processing chamber having a substrate support assembly of the present invention;

[0023] **FIG. 2** is a partial sectional view of another embodiment of a substrate support assembly;

[0024] **FIG. 2A** is a partial sectional view of another embodiment of a substrate support assembly;

[0025] **FIG. 3** is a flow diagram of one embodiment of a method for fabricating a substrate support assembly;

[0026] **FIG. 4** is a flow diagram of another embodiment of a method for fabricating a substrate support assembly;

[0027] **FIG. 5** is a partial sectional view of another embodiment of a substrate support assembly; and

[0028] **FIG. 6** is a partial sectional view of another embodiment of a substrate support assembly;

[0029] **FIG. 7** is a partial sectional view of another embodiment of a substrate support assembly;

[0030] **FIG. 7A** is a partial sectional view of another embodiment of a substrate support assembly;

[0031] **FIG. 8** is a flow diagram of one embodiment of a method for fabricating a substrate support assembly;

[0032] **FIG. 9** is an exploded isometric view of a substrate support assembly, in one embodiment;

[0033] **FIG. 10** is a side view of the substrate support assembly of **FIG. 9**.

[0034] To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures.

DETAILED DESCRIPTION

[0035] The invention generally provides a large area substrate support and methods for fabricating the same. The invention is illustratively described below in reference to a plasma enhanced chemical vapor deposition system for processing large area substrates, such as a plasma enhanced chemical vapor deposition (PECVD) system, available from AKT, a division of Applied Materials, Inc., Santa Clara, Calif. In one embodiment, the processing chamber is adapted to process large area substrate that have a surface area of at least about 2000 cm^2. In another embodiment, the processing chamber is adapted to process substrates that have a surface area of at least about 6,716 cm^2 (e.g., 730 mm×920 mm). However, it should be understood that the invention has utility in other system configurations such as physical vapor deposition systems, ion implant systems, etch systems, other chemical vapor deposition systems and any other system in which processing a substrate on a substrate support is desired.

[0036] **FIG. 1** is a cross sectional view of one embodiment of a plasma enhanced chemical vapor deposition system **100**. The system **100** generally includes a chamber **102** coupled to a gas source **104**. The chamber **102** has walls **106**, a bottom **108** and a lid assembly **110** that define a process volume **112**. The process volume **112** is typically accessed through a port (not shown) in the walls **106** that facilitates movement of a large area glass substrate **140** into and out of the chamber **102**. The walls **106** and bottom **108** are typically fabricated from a unitary block of aluminum or other material compatible for processing. The lid assembly **110** contains a pumping plenum **114** that couples the process volume **112** to an exhaust port (not shown) that is coupled to various pumping components (not shown).

[0037] The lid assembly **110** is supported by the walls **106** and can be removed to service the chamber **102**. The lid assembly **110** is generally comprised of aluminum. A distribution plate **118** is coupled to an interior side **120** of the lid assembly **110**. The distribution plate **118** is typically fabricated from aluminum. The center section includes a perforated area through which process and other gases supplied from the gas source **104** are delivered to the process volume **112**. The perforated area of the distribution plate **118** is configured to provide uniform distribution of gases passing through the distribution plate **118** into the chamber **102**.

[0038] A substrate support assembly **138** is centrally disposed within the chamber **102**. The substrate support assembly **138** supports the large area glass substrate **140** (herein after "substrate **140**") during processing.

Coated Susceptor Design

[0039] In one embodiment, the substrate support assembly **138** generally includes an electrically conductive body **124** that is covered with an electrically insulative coating **180** over at least the portion of the body **124** that supports the substrate **140**. The electrically insulative coating **180** has a surface finish of about 200 to about 2000 micro-inches is believed to improve deposition uniformity without expensive aging or plasma treatment of the substrate support assembly **138**. The surface finish is characterized by an average surface roughness (Ra) or Arithmetical Average (AA). The electrically insulative coating **180** may also cover other portions of the body **124**. It is believed that the rougher surface offsets the effect of glass substrate thickness variation to provide a more uniform capacitance across the substrate, thereby enhancing plasma and deposition uniformity, and substantially eliminating the formation of thin spots in the deposited film.

[0040] Also, since it is believed that the reduced contact between the substrate and the electrically insulative coating **180** will reduce the charge transfer caused by the reduced amount of contacting surface area, or the increase roughness improves electrical contact which reduces the difference in charge between the two parts, the possibility of ESD metal line arcing and particle attraction to the surface of the substrate will be reduced.

[0041] The conductive body **124** may be fabricated from metals or other comparably electrically conductive materi-

als. The electrically insulative coating **180** may be a dielectric material such as oxides, silicon nitride, silicon dioxide, aluminum dioxide, tantalum pentoxide, silicon carbide, polyimide, among others, which may be applied by various deposition or coating processes, including but not limited to, flame spraying, plasma spraying, high energy coating, chemical vapor deposition, spraying, adhesive film, sputtering and encapsulating.

[**0042**] In one embodiment, the substrate support assembly **138** includes an aluminum conductive body **124** that encapsulates at least one embedded heating element **132** and a thermocouple **190**. At least a first reinforcing member **116** is generally embedded in the body **124** proximate the heating element **132**. A second reinforcing member **166** may be disposed within the body **124** on the side of the heating element **132** opposite the first reinforcing member **116**. The reinforcing members **116** and **166** may be comprised of metal, ceramic or other stiffening materials. In one embodiment, the reinforcing members **116** and **166** are comprised of aluminum oxide fibers. Alternatively, the reinforcing members **116** and **166** may be comprised of aluminum oxide fibers combined with aluminum oxide particles, silicon carbide fibers, silicon oxide fibers or similar materials. The reinforcing members **116** and **166** may include loose material or may be a pre-fabricated shape such as a plate. Alternatively, the reinforcing members **116** and **166** may comprise other shapes and geometry. Generally, the reinforcing members **116** and **166** have some porosity that allows aluminum to impregnate the members **116**, **166** during a casting process described below.

[**0043**] The heating element **132**, such as an electrode disposed in the substrate support assembly **138**, is coupled to a power source **130** and controllably heats the substrate support assembly **138** and substrate **140** positioned thereon to a predetermined temperature. Typically, the heating element **132** maintains the substrate **140** at a uniform temperature of about 150 to at least about 460 degrees Celsius.

[**0044**] Generally, the substrate support assembly **138** has a lower side **126** and an upper side **134** that supports the substrate. The lower side **126** has a stem cover **144** coupled thereto. The stem cover **144** generally is an aluminum ring coupled to the substrate support assembly **138** that provides a mounting surface for the attachment of a stem **142** thereto.

[**0045**] Generally, the stem **142** extends from the stem cover **144** and couples the substrate support assembly **138** to a lift system (not shown) that moves the substrate support assembly **138** between an elevated position (as shown) and a lowered position. A bellows **146** provides a vacuum seal between the process volume **112** and the atmosphere outside the chamber **102** while facilitating the movement of the support assembly **138**. The stem **142** additionally provides a conduit for electrical and thermocouple leads between the substrate support assembly **138** and other components of the system **100**.

[**0046**] The substrate support assembly **138** generally is grounded such that RF power supplied by a power source **122** to the distribution plate **118** (or other electrode positioned within or near the lid assembly of the chamber) may excite the gases disposed in the process volume **112** between the substrate support assembly **138** and the distribution plate **118**. The RF power from the power source **122** is generally selected commensurate with the size of the substrate to drive the chemical vapor deposition process.

[**0047**] The substrate support assembly **138** additionally supports a circumscribing shadow frame **148**. Generally, the shadow frame **148** prevents deposition at the edge of the substrate **140** and substrate support assembly **138** so that the substrate does not stick to the support assembly **138**.

[**0048**] The substrate support assembly **138** has a plurality of holes **128** disposed therethrough that accept a plurality of lift pins **150**. The lift pins **150** are typically comprised of ceramic or anodized aluminum. Generally, the lift pins **150** have first ends **160** that are substantially flush with or slightly recessed from an upper side **134** of the substrate support assembly **138** when the lift pins **150** are in a normal position (i.e., retracted relative to the support assembly **138**). The first ends **160** are generally flared to prevent the lift pins **150** from falling through the holes **128**. Additionally, the lift pins **150** have a second end **164** that extends beyond the lower side **126** of the support assembly **138**. The lift pins **150** may be actuated relative to the substrate support assembly **138** by a lift plate **154** to project from the upper side **134**, thereby placing the substrate in a spaced-apart relation to the support assembly **138**.

[**0049**] The lift plate **154** is disposed proximate the lower side **126** of the support surface. The lift plate **154** is connected to the actuator by a collar **156** that circumscribes a portion of the stem **142**. The bellows **146** includes an upper portion **168** and a lower portion **170** that allow the stem **142** and collar **156** to move independently while maintaining the isolation of the process volume **112** from the environment outside the chamber **102**. Generally, the lift plate **154** is actuated to cause the lift pins **150** to extend from the upper side **134** as the substrate support assembly **138** and the lift plate **154** move closer together relative to one another.

[**0050**] **FIGS. 2 and 2**A are a partial sectional view of one another embodiment of a substrate support assembly **138**, this embodiment is labeled hereafter as support assembly **200** to avoid confusion. The support assembly **200** includes a body **202**, which may be aluminum, is substantially covered with an anodized coating **210**. The body **202** may be comprised of one or more coupled members or a unitary casted body having the heating element **132** embedded therein. Examples of substrate support assemblies that may be adapted to benefit from the invention are described in U.S. patent application Ser. No. 10/308,385 filed Dec. 2, 2002, and Ser. No. 09/921,104 filed Aug. 1, 2001, both of which are hereby incorporated by reference in there entireties.

[**0051**] The body **202** generally includes a substrate support surface **204** and an opposing mounting surface **206**. The mounting surface **206** is coupled to the stem **142** (seen in **FIG. 1**). The anodized coating **210** covers at least the substrate support surface **204** of the body **202** and provides a separating layer between the substrate **140** and the substrate support surface **204**.

[**0052**] Referring to **FIG. 2A**, the coating **210** includes an outer surface **212** and an inner surface **214**. The inner surface **214** is generally disposed directly on the body **202**. In one embodiment, the anodized coating has a thickness of between about 0.3 mils (7.6 micrometers) to about 2.16 mils (54.9 micrometers). Anodized coatings having a thickness falling outside of this range tend to either fail during temperature cycling or do not sufficiently reduce spotting in SiN, αSi and n+α-Si large area films formed by PECVD deposition.

[0053] Referring to **FIGS. 2 and 2**A, a portion **218** of the outer surface **212** positioned above the substrate support surface **204** has a geometry configured to support the substrate **140** thereon. The portion **218** of the outer surface **212** has a coated surface finish **216** of a predefined roughness that promotes uniform thickness of films deposited on the substrate **140**. The coated surface finish **216** has a roughness of about 200 to about 2000 micro-inches. The coated surface finish **216** advantageously results in improved film thickness uniformity and particularly has been found to substantially eliminate local thickness non-uniformity (spots of thin deposition) without conditioning (e.g., aging) the substrate support. The elimination of substrate support conditioning conserves both time and materials normally consumed in a plasma aging process and eliminates vacuum purges between cycles, the elimination of which results in improved system throughput. In one embodiment, the coated surface finish **216** has a roughness of about 330 micro-inches.

[0054] The coated surface finish **216** of the anodized coating **210** may be achieved by treating at least a portion **220** of the outer substrate support surface **204** underlying the substrate **140** and/or by treating at least the anodized coating **210** that supports the substrate **140** (to obtain a pre-defined surface finish **208**). The surface finish **208** of the substrate support surface **204** may be formed in a number of manners, including bead blasting, abrasive blasting, grinding, embossing, sanding, texturing, etching or other method for providing a pre-defined surface roughness. In one embodiment, the surface finish **208** of the substrate support surface **204** of the body **202** is about 200 to about 2000 micro-inches. In another embodiment, the surface finish **208** is about 330 micro-inches.

[0055] Optionally, a strip **224** of the substrate support surface **204** bounding the portion **220** positioned out from under the substrate **140** may be left untreated to minimize the fabrication costs. This results in a strip **222** of the anodized coating **210** above the untreated strip **224** that may have a finish different than the finish **216**, but as the strip **222** is beyond the substrate **140**, the surface finish of the strip **222** has no effect on film deposition uniformity. In one embodiment, the strip **222** of the anodized coating **210** has a smoother surface finish than the portion **218** of the anodized coating **210** it bounds.

[0056] **FIG. 3** depicts one embodiment of a method **300** for fabricating the support assembly **138**. The method begins at step **302** by preparing the substrate support surface **204** of the body **202**. The preparing step **302** generally entails working or otherwise treating the substrate support surface **204** so that the surface finish **208** is between about 200 to about 2000 micro-inches. The surface finish **208** is characterized by an average surface roughness (Ra) or Arithmetical Average (AA). In one embodiment, the preparing step **302** may include bead blasting, abrasive blasting, grinding, embossing, sanding, texturing, etching or other method for providing a pre-defined surface roughness, for example, about 330 micro-inches. To achieve a surface roughness greater than 500 micro-inches to about 2000 micro-inches it is common to use milling, lathe cutting, knurling, flame cutting or other similar metal removal techniques.

[0057] In one embodiment of step **302**, the substrate support surface **204** is flame, arc or plasma sprayed with a material, such as, for example, aluminum (Al), alumina (Al_2O_3), titanium (Ti), or stainless steel, to achieve a desired roughness in the range between about 200 and about 2000 micro-inches. In one aspect, the substrate support surface **204** is coated with an arc sprayed aluminum material to achieve a roughness of about 200 to about 2000 micro-inches.

[0058] In one embodiment, the substrate support surface **204** is bead blasted to a pre-determined surface finish. Bead blasting may include impacting the body **202** with a garnet, ceramic or glass bead.

[0059] In another embodiment, the bead is aluminum oxide, having an average diameter of about 125 to about 375 micron. The beads are provided through a nozzle having an exit velocity sufficient to produce a surface finish **208** of about 200 to about 2000 micro-inches.

[0060] After the completion of the preparing step **302**, the body is anodized at step **304**. The anodizing step **304** generally includes applying an anodized layer having a thickness between about 0.3 to about 2.16 mils. The resultant coated surface finish **216** on the outer surface **212** of the anodized coating **212** is about 200 to about 2000 micro-inches, and preferably between about 300 and about 1000 micro-inches, and more preferably between about 330 and about 500 microinches.

[0061] **FIG. 4** depicts another embodiment of a method **400** of fabricating a support assembly **138**. The method begins at step **402** by anodizing the body **202**. At step **404**, at least a portion **218** of the outer surface **212** of the anodized coating **210** is treated to provide a roughened coated surface finish **216**. Alternatively, other portions of the outer surface **212** may be treated.

[0062] The treating step **404** may include bead blasting, abrasive blasting, grinding, milling, embossing, sanding, texturing, etching or other method for providing a pre-defined surface roughness. In one embodiment, the treating step **404** results in a surface finish of the outer surface of about between about 200 to about 2000 micro-inches, and preferably between about 300 and about 1000 micro-inches, and more preferably between about 330 and about 500 micro-inches.

[0063] **FIG. 5** depicts a partial sectional view of another embodiment of a support assembly **500** configured to enhance uniform deposition thickness. The support assembly **500** includes an aluminum support body **502** substantially encapsulated by an anodized coating **506**. A heating element **504** is coupled to the support body **502** to control the temperature of the substrate **140** positioned on the upper surface of the support assembly **500**. The heating element **504** may be a resistive heater or other temperature control device coupled to or disposed against the body **502**. Alternatively, a lower portion **512** of the body **502** may be free from anodization to provide direct contact between the heating element **504** and the body **502**. Optionally, an intervening layer (not shown) of thermally conductive material may be disposed between the heating element **504** and the lower portion **512** of the body **502**.

[0064] An upper portion **508** of the anodized coating **506** that supports the substrate **140** has a surface finish **510** configured to enhance uniform deposition of films on the substrate **140**. In one embodiment, the surface finish **510** has

a roughness between about 200 to about 2000 micro-inches, and preferably between about 300 and about 1000 micro-inches, and more preferably between about 330 and about 500 micro-inches. The surface finish **510** may be created through a number of methods, including the methods described above.

[**0065**] **FIG. 6** depicts another embodiment of a heater assembly **600**. The heater assembly **600** includes an aluminum body **602** having an anodized coating **606** at least partially formed thereon. A heating element **604**, i.e., a conduit through which a temperature-controlled fluid is circulated, is disposed against a bottom surface of the body **602** to facilitate temperature control of the substrate **140**. Optionally, a thermally conductive plate **614** may be disposed between the heating element **604** and the body **602** in order to enhance temperature uniformity between the heating element **604** and the body **602**. In one embodiment, the intervening layer **614** is a copper plate.

[**0066**] A clamp plate **608** is coupled to the body **602** by a plurality of fasteners **610** (one of which is shown in **FIG. 6**) that thread into a threaded hole **612** formed in the body **602**. The clamp plate **608** sandwiches the heating element **604** with the body **602**, thereby enhancing heat transfer.

[**0067**] A portion **620** of the anodized coating **606** that supports the substrate **140** has a surface finish **622** configured to enhance uniform deposition of films on the substrate **140**. The surface finish **622** may be created similar to that described above.

[**0068**] Thus, a support assembly that enhances uniform deposition of films disposed on a large area substrate is provided. At least a portion of an anodized coating covering the aluminum body of the support assembly which supports the substrate is textured to a pre-determined surface roughness that enhances deposition uniformity, thereby substantially eliminating time-consuming aging of the support assembly and its associated costs.

Non Coated Susceptor

[**0069**] **FIGS. 7 and** 7A are a partial sectional view of one another embodiment of a substrate support assembly **138** that is uncoated, and will be labeled hereafter as substrate support assembly **700** to avoid confusion. The support assembly **700** includes a bare, or uncoated, body **702**. The body **702** may be comprised of one or more coupled members or a unitary casted body having the heating element **132** embedded therein. In one embodiment, the body **702** is made from metal, such as, for example, aluminum (Al), titanium (Ti) or stainless steel.

[**0070**] The body **702** generally includes a substrate support surface **704** and an opposing mounting surface **706**. The mounting surface **706** is coupled to the stem **142** (seen in **FIG. 1**).

[**0071**] Referring to **FIGS. 7 and** 7A, the substrate support surface **704** has a geometry configured to support the substrate **140** thereon. The substrate contact portion **720** of the substrate support surface **704** has a surface finish **714** of a predefined roughness that promotes uniform thickness of films deposited on the substrate **140**. The surface finish **714** has a roughness of about 80 to about 2000 micro-inches. The surface finish **714** advantageously results in improved film thickness uniformity and particularly has been found to substantially eliminate local thickness non-uniformity (spots of thin deposition). In one embodiment, the surface finish **714** has a roughness greater than about 140 micro-inches. In another embodiment the surface finish **714** has a roughness greater than about 340 micro-inches. In one aspect, it may be desirable to leave the area **722** outside the substrate contact portion **720**, side edge **734** and opposing mounting surface **706** in an unroughened or partially roughened state to reduce the cost of forming the substrate support assembly **700**.

[**0072**] **FIG. 8** depicts one embodiment of a method **800** for fabricating the support assembly **138**. The method begins at step **802** by preparing the support surface **704** of the body **702**. The preparing step **802** generally entails working or otherwise treating the support surface **704** so that the surface finish **714** is between about 140 to about 2000 micro-inches, and preferably between about 300 and about 1000 micro-inches, and more preferably between about 330 and about 500 micro-inches. The finish **714** is characterized by an average surface roughness (Ra) or Arithmetical Average (AA). In one embodiment, the preparing step **802** may include bead blasting, abrasive blasting, grinding, embossing, sanding, texturing, etching or other method for providing a pre-defined surface roughness, for example, about 330 micro-inches. To achieve a surface roughness greater than 500 micro-inches to about 2000 micro-inches it is common to use milling, lathe, knurling, flame cutting or other similar metal removal techniques.

[**0073**] In one embodiment, an optional surface coating step **804** is used to form a rough surface on which the substrate is supported. The surface coating step **804** may be performed on the support surface **704** by use of conventional flame, arc or plasma sprayed metals, such as, for example, aluminum (Al), titanium (Ti), or stainless steel, to achieve a desired roughness in the range between about 140 and about 2000 micro-inches. In one aspect, the support surface **704** of a body **702** which is made of aluminum is coated with an arc sprayed aluminum material to achieve a roughness greater than about 140 micro-inches.

[**0074**] In another embodiment of the optional step **804**, a ceramic or metal oxide coating is deposited on the support surface **704** by use of a conventional flame, arc or plasma spray process to achieve a surface roughness between about 80 and 2000 micro-inches. For example an aluminum oxide (Al_2O_3) may be deposited on the support surface **704** to achieve a surface roughness between about 140 and about 2000 micro-inches.

Substrate Support Structure

[**0075**] The various aspects of the invention discussed above generally discuss various embodiments that can improve the substrate process results on large area substrates by improving the various properties or features of the substrate support assembly (e.g., elements **138**, **200**, **700**). To achieve desirable and repeatable process results process results on large area substrates, one generally needs to assure that the contact between the substrate and the substrate support is relatively uniform and repeatable. To assure that the contact is relatively uniform and repeatable the substrate support surface generally needs to be formed into and remain in a desired and a repeatable shape. Referring to **FIGS. 9 and 10**, due to the size of the substrate support **910** and the temperatures commonly achieved during processing (e.g., typically 150° C. to 460° C.) one may often need to

provide structural support (e.g., element **910**) to the substrate support **902** to prevent it from deflecting due to gravity and softening of the material from which the substrate support **902** is formed. This issue commonly arises when using substrate supports **902** that are made of aluminum, due to the nature of the aluminum material at these temperatures. An exemplary design of a support structure that is internal to the substrate support **902** that is adapted to resist deflection during high temperature processing is further described in the commonly assigned U.S. Pat. No. 6,554,907, which is hereby incorporated by reference in its entirety to the extent not inconsistent with the claimed invention. An exemplary design of a support structure that is external to the substrate support **902** that is adapted to resist deflection during high temperature processing is further described in the commonly assigned U.S. patent application Ser. No. 11/143,506 [AMAT 9182], filed Jun. 2, 2005, which claims the benefit of U.S. Provisional Patent Application Ser. No. 60/587,173, filed Jul. 12, 2004, which is hereby incorporated by reference in its entirety to the extent not inconsistent with the claimed invention.

[**0076**] **FIG. 9** illustrates an explode isometric view of a substrate support structure **910** that may be used in place of the substrate support assembly **138** shown in **FIG. 1**. **FIG. 10**, illustrates a side view of the substrate support structure **910** in its fully assembled orientation that has a substrate **140** positioned on the substrate supporting surface **904**. The substrate support structure **910** of **FIGS. 9 and 10** generally includes a base structure **914** under the substrate support **902**. In one aspect, the substrate support **902** is supported by the base structure **914** that is connected and supported by the shaft **142** at the connection point **901**. In one embodiment, the base structure **914** is adapted to provide continual support to the substrate support **902** to assure that the substrate supporting surface **904** remains a desired predetermined shape before, during and after performing the various processes. The substrate support **902** described in conjunction with the support structure **910**, generally can be formed by any of the processes described above (e.g., described in relation to elements **202**, **502**, **602**, **702**).

[**0077**] The base structure **914** generally contains elongated base support plate **915** and a plurality of lateral support plates **917** that are adapted to support the substrate support **902**. In the configuration shown in **FIG. 9** the lateral supports are disposed in an orientation that is generally transverse to the base support plate **915**. In one aspect, it is preferred that the plates **915**, **917** be fabricated from a material of sufficient strength and rigidity to support and retain the weight of the substrate support **902** under the processing temperature and pressure conditions. For example, the plates **915**, **917** are made from a ceramic material, such as, alumina (Al_2O_3) or a heat resistant metal such as a 300 series stainless steel.

[**0078**] It is understood that the substrate support **902** rests immediately on the support plates **915**, **917** although the view of **FIG. 9** shows the substrate support assembly **910** exploded for purposes of explanation. It is contemplated that the substrate support **902** and support plates **915**, **917** do not move relative each other during processing. Also, referring to **FIG. 9**, while one base support plate **915** and four separate lateral support plates **917** are shown, it is to be under stood that any number of support plates **915**, **917** may be used.

[**0079**] In one embodiment, the base structure **914** may be formed in a non-planar shape in order to impart a non-planar profile to the substrate support **902** and supported substrate **140**. In this embodiment, the base structure **914** may contain an elongated base support plate **915**, a plurality of lateral support plates **917** disposed generally transverse to the base support plate **915**, and a plurality of shims **918** of varying thicknesses that are placed on the lateral support plates **917** to support the substrate support **902** and achieve a desired non-planar profile. Preferably, the thickness of the shims **918** is from about 0.4 mm to about 3.5 mm. In this embodiment, the shims **918** are positioned at ends of the lateral support plates **917** however; the shims **918** may be located on other portions of the lateral support plates **917**. It is contemplated that the shape of the support plates **917** and/or the use of shims **918** will allow pre-shaping of the substrate support **902** that will translate a desired planar orientation to a substrate during processing as the heated substrate will conform to the planar orientation of the substrate support **902** during processing.

[**0080**] Although several preferred embodiments which incorporate the teachings of the present invention have been shown and described in detail, those skilled in the art can readily devise many other varied embodiments that still incorporate these teachings.

1. A substrate support adapted to support large area substrates comprising:

an electrically conductive body having a substrate support surface;

an electrically insulative coating disposed on the body; and

at least a portion of the coating disposed over a center of the substrate supporting surface having a surface finish between about 200 and about 2000 micro-inches.

2. The substrate support of claim 1, wherein the electrically conductive body is at least partially fabricated from aluminum body and the coating is an anodization layer.

3. The substrate support of claim 2, wherein the anodized coating has a thickness of about 0.3 to about 2.16 mils.

4. The substrate support of claim 1, wherein the substrate support surface has a surface finish between about 300 and about 1000 micro-inches.

5. The substrate support of claim 4, wherein the substrate support surface is bead blasted.

6. The substrate support of claim 1, wherein the coating disposed on the substrate support surface further comprises:

a strip circumscribing the portion of the coating centered on the substrate support surface and having a surface finish less than about 200 micro-inches.

7. The substrate support of claim 1, wherein the substrate support surface further comprises:

a center region having a surface finish between about 300 and about 1000 micro-inches; and

a perimeter region circumscribing the center region and having a surface finish less than about 300 micro-inches.

8. The substrate support of claim 1, wherein the surface area of the substrate support surface is at least 2,000 cm^2.

9. A substrate support adapted to support large area substrates comprising:

a body having a substrate support surface;

a substrate support structure having one or more supports that are adapted to structurally support the body during processing; and

an electrically insulative coating disposed on the substrate support surface treated after deposition to a surface finish between about 200 and about 2000 micro-inches.

10. The substrate support of claim 9, wherein the body is aluminum and the coating is an anodization layer.

11. The substrate support of claim 9, wherein the substrate support surface is treated by at least one of bead blasting, abrasive blasting, grinding, embossing, sanding, texturing, etching, milling, lathe cutting, knurling, or flame cutting.

12. The substrate support of claim 9, wherein the substrate support surface is blasted with aluminum oxide media having an average diameter of about 125 to about 375 microns.

13. A substrate support fabricated by a process comprising:

providing a conductive body having a substrate support surface that is adapted to support a large area substrate; and

coating the substrate support surface, wherein the coating has a surface roughness between about 330 and about 1000 micro-inches.

14. The substrate support of claim 13, wherein the coating is an anodized coating that is performed on a conductive body that contains aluminum.

15. The substrate support of claim 13, wherein the step of providing a conductive body assembly further comprises:

providing a substrate support structure having one or more supports; and

positioning the conductive body on the one or more supports.

16. The substrate support of claim 13 further comprising:

treating the substrate support surface before coating to yield a surface finish of about 300 to about 2000 micro-inches on the body.

17. The substrate support of claim 16, wherein the step of treating the substrate support surface further comprises:

performing at least one treatment selected from a group consisting of bead blasting, abrasive blasting, grinding, embossing, sanding, texturing, etching, milling, lathe cutting, knurling, or flame cutting.

18. The substrate support of claim 16, wherein the step of treating the substrate support surface further comprises:

bead blasting the substrate support surface, wherein bead blasting includes impacting the substrate support surface with beads having an average diameter of about 125 to about 375 microns.

19. The substrate support of claim 13, further comprising:

encapsulating a heating element in the conductive body, wherein the conductive body contains aluminum.

20. The substrate support of claim 13, further comprising:

coupling a heating element to the conductive body opposite the substrate support surface.

21. A substrate support fabricated by the process comprising:

treating an aluminum substrate support surface adapted to support a large area substrate to obtain a surface finish of about 300 to about 2000 micro-inches; and

anodizing the substrate support surface to a thickness of about 0.3 to about 2.16 mils, wherein the surface finish of the anodized coating disposed at least over the center portion of the substrate support surface has a surface finish of between about 300 and about 2000 micro-inches.

22. A substrate support adapted to support large area substrates comprising:

an electrically conductive body having a substrate support surface, wherein the substrate support surface is bare aluminum and has a surface finish between about 140 and about 2000 micro-inches.

23. A substrate support adapted to support large area substrates comprising:

an bare aluminum body having a substrate support surface treated to a surface finish of about 80 to about 1000 micro-inches; and

a substrate support structure having one or more supports that are adapted to structurally support the aluminum body during processing.

24. The substrate support of claim 23, wherein the substrate support surface is treated by a process selected from a group consisting at least one of bead blasting, abrasive blasting, grinding, embossing, sanding, texturing, etching, milling, lathe cutting, knurling, or flame cutting.

25. The substrate support of claim 23, wherein the substrate support surface is blasted with aluminum oxide media having an average diameter of about 125 to about 375 microns.

* * * * *